This document includes Appendix A: Rules for Significant Figures, of the Draft EPA Report "Surface Vessel Bilgewater/Oil Water Separator Feasibility Impact Analysis Report" published in 2003. The reference number is: EPA-842-D-06-019

DRAFT
Feasibility Impact Analysis Report
Surface Vessel Bilgewater/Oil Water Separator

Appendix A: Rules for Significant Figures

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The Uniform National Discharge Standards' Surface Vessel Bilgewater Feasibility Impact Analysis Report (FIAR) abides by the following rules for significant figures:

1. Reporting Values: To report values that are subject to the application of significant figures, the following rules are used:

    - All non-zero digits are significant (e.g., *482* has three significant digits).

    - Zeros between significant digits are significant (e.g., *906* has three significant digits).

    - Zeros to the right of the decimal after significant digits are significant (e.g., *7.0* has two significant digits). Zeros to the left of significant digits are not significant (e.g., *0.004* has one significant digit).

    - Decimal points indicate the position of estimation in a number. Scientific notation may be used to remove ambiguity. See examples below:

        – *20,000* has one significant digit. (Note the absence of a decimal point in this number.)
        – *20,000.* has five significant digits.
        – *3.0000 x 10^7* has five significant digits.

2. Performing Mathematical Operations: When performing mathematical operations in the feasibility analyses, the following rules apply.

    - *Addition and Subtraction:* The least precise number used in the operation determines the result of the operation, as shown below:

        101 + 1,425,600 = 1,425,700

        Note the value of *1,425,700* is not significant before the hundreds' place. Therefore, the level of precision is limited to the hundreds' place; the tens and ones place are not reported. Therefore, the result is reported as *1,425,700* rather than *1,425,701*.

    - *Multiplication and Division:* The number of significant digits in a product or quotient is equal to the number of significant digits in the value with the least number of significant digits used in the operation (e.g., *23.01 x 43,000 / 7931.074 = 120*).

    - *Logarithms:* The mantissa will possess the same number of significant digits as the value upon which the operation is performed. Conversely, when performing an antilogarithm the result will possess as many significant figures as were present in the mantissa of the logarithm, as demonstrated below.

– *log(0.07802) = -1.1078*
– *antilog(1.068) = 11.7*

NOTE: A calculated value is reported with the appropriate number of significant digits. However, when that value is used in a subsequent operation, the calculated value, rather than the reported value, is used for that operation (although the reported value is shown in subsequent equations).

3. Rounding: After performing mathematical operations, the resulting value may have more digits than can be reported per the rules of significant figure usage. In these instances, the value must be rounded to the proper number of significant digits using the following rules. (For clarity, in these guidelines only, the operation results are displayed in parentheses to eight digits.)

- If the digit to the right of the last significant digit is less than *5*, drop all digits to the right of the last significant digit [e.g., *2.99 x 1.20773 = 3.61 (3.6111127)*].

- If the digit to the right of the last significant digit is greater than *5*, increase the last significant digit by *1* [e.g., *53.826 x 88.04 = 4739 (4738.8410)*].

- If the digit to the right of the last significant digit is *5*, round up. If the digit to the right of the last significant digit is *<5*, round down, as demonstrated below:
  – *31.50* rounds up to *32*
  – *32.49* rounds down to *32*

4. Exact Numbers: Exact numbers are defined values (e.g., *7 days per week*). Because an exact number does not affect the accuracy of an operation, such numbers are considered to have an infinite number of significant digits.

5. Financial calculations: In the UNDS program, dollar amounts are rounded to the nearest whole dollar value, even if the fractional values are significant (e.g., *$27.84 x 23.715 = $660*).

6. Calculating Annual Labor Cost: The proportion of labor to marine pollution control device (MPCD) operation hours is defined as an exact ratio. Therefore, the resulting value will be treated as an exact value as well. For example, the annual labor cost associated with supervision of the gravity coalescer is the hours of gravity coalescer operation per year (*92 hrs/yr*), multiplied by the amount of time required to supervise the gravity coalescer operation (*15 minutes per every two hours of OWS operation*), multiplied by the labor rate (*$23.35/hour*), as shown below.

(92 operation hrs/yr) x (0.25 labor hr / 2 operation hrs) x ($23.35/labor hr) = $270/yr

7. Calculating Processing Time: If the vessel's annual generation rate of bilgewater and the MPCD's processing rate are known, the number of hours the MPCD operates annually can be calculated. However, process knowledge is required to determine the number of significant digits in the original values. For example, if the volume of bilgewater generated is an approximate value of *55,000 gallons* with a precision of *+/-1000 gallons,* the value *55,000* has two significant digits. If the MPCD (e.g., gravity coalescer) has a

reported processing rate of *10 gpm,* the value appears to have one significant digit; however, from process knowledge, the performance specification is known to be *10 ± 1% gpm*. As such, the processing rate (*10 gpm*) has two significant digits. Consequently, the processing time is reported as *92 hours* because both the volume of bilgewater generated and the processing rate have two significant digits. (The conversion from minutes to hours (*60 min/hr*) is an exact number.)

(55000 gal/yr) / (10.0 gal/min) / (60 min/hr) = 92 hr/yr

Table A-1 provides a list of specific parameters included in the Surface Vessel Bilgewater FIAR and whether the rules of significant figures are applicable to them.

Table A-1. Application of Significant Figure Rules to

Parameters Included in the Surface Vessel Bilgewater FIAR

Parameter	Application of Significant Rules?
Generation rate	Yes
Operating profile (days in port and underway outside 12nm)	Yes
MPCD processing rates	Yes
Transfer pump rates	Yes
Waste oil volume (i.e., *1%* of the annual bilgewater volume generated while operating within 12 nm from shore)	No. This value represents an assumption made by equipment experts that the volume of waste oil generated is 1% of the annual bilgewater generated while operating within 12nm from shore. This assumption is used for all MPCDs considered. Assumptions that are universal to all MPCDs are treated as exact numbers so that MPCDs can be compared with the highest level of precision possible.
MPCD oversight labor hours (i.e., *0.25 hours* of oversight for each two hours of MPCD operation)	No. This value represents an assumption made by equipment experts that 0.25 labor hours of supervision are required for every 2 hours of MPCD operation. This assumption is used for all MPCDs considered. Assumptions that are universal to all MPCDs are treated as exact numbers so that MPCDs can be compared with the highest level of precision possible.
Labor rate for FY 1999 (i.e., *$22.64* per hour)	No. Based on Navy experience, it was assumed the E-5 pay grade would perform the majority of labor. Therefore, the E-5 pay rate of *$22.64 per hour* is considered to be an exact number.
Procurement cost	No. A third party provided this value. As such, it is treated as an exact number.
Installation cost	Yes
Development of technical manuals	Yes
Training material cost	Yes
Unit electrical requirements	No. A third party provided this value. As such, it is treated as an exact number.
Vessel's total electrical capacity	No. The vessel's total electrical capacity was assumed to equal its design capacity. As such, it is treated as an exact number.
30-day time period required for *In Situ* biological treatment to establish a population of microbes to digest the bilgewater's oil content.	No. A third party provided this value. As such, it is treated as an exact number.
ACEIT cost model	No. The cost model performs programmed calculations, which are treated as exact numbers.
Time-based maintenance	Yes
Condition-based maintenance	Yes
Consumer price index	Yes
Discount rate	No. A third party provided this value. As such, it is treated as an exact number.